MODIS Annual Report, Dec 1997

Y. Kaufman, D. Tanré, B.-C. Gao
L. Remer, A. Chu, S. Mattoo, A. Wald, R. Kleidman, R.-R. Li and R. Fraser

This is the annual report, covering the **aerosol ocean** and **aerosol land** algorithm, and our involvement in the **NIR water vapor** algorithm and the **fire algorithm**.

Main topics addressed in this period:

1. Version 2 algorithms for all products delivered. (*Chu, Mattoo,Li,Kaufman, Tanré*)
2. MODIS atmosphere QA plan developed (*Chu*).
3. Analysis of SCAR and TARFOX experiment data for MODIS algorithm validation*(Kaufman, Tanré, Kleidman, Ji, Mattoo, Remer, Li, Chu, Yamasoe)*
4. Analysis of data from laboratory experiment, in the Forest Service Fire Lab. to understand the fire products. *(Kaufman, Wald),*
5. Development of a new technique for remote sensing of dust over land using IR channels, to supplement present algorithm for remote sensing of aerosol from MODIS *(Wald ,Tanre, Kaufman)*
6. Surface properties in the mid-IR and the visible: *(Wald, Karnieli, Kaufman, Remer, Mekler, Ji)*
7. Analysis of smoke effects on column stability (*Remer, Joseph)*
8. Study of vegetation indices. (*Kaufman, Li*)
9. SeaWiFS algorithm comparison (*Fraser*)
10. Aerosol group web page organized (*Ramaprasad, Remer, Kaufman*)
11. MODIS cloud mask analyzed, evaluated and customized (*Ji, Li, Chu, Remer*)
12. Meetings attended: *(Kaufman, Tanré, Remer, Fraser, Wald, Ji, Li, Chu, Kleidman, Mattoo, Ramaprasad*)
13. Publication of JGR special issue on remote sensing of aerosol and atmospheric correction (*Kaufman, Tanré,Fraser, Remer, Mattoo, Chu*)
14. Papers published. *(Kaufman, Fraser, Wald, Remer, Gao, Li*)
15. Papers submitted *(Kaufman, Ji, Wald, Remer, Chu, Kleidman, Yamasoe*)

Topics postponed (or continued) to next year

1. Smoke-cloud interaction analysis - second part
2. Dust aerosol model (Tanré, Fraser)
3. Comparison of IR dust retrieval with AVHRR retrieval for selected images near African coast.

Plans for the next year:

1. Setting the hardware and software structure for EOS-AM1 launch, data checking and validation, beginning of the validation process

2. In depth analysis of Israel spectra data for the aerosol algorithm assumptions testing and vegetation indices analysis. Setting a web based data base
3. Continued test of the aerosol and water vapor algorithm over land and ocean
4. Study of the MODIS fire products in the laboratory and SCAR-B data
5. Preparation for the use of MODIS data for assessment of aerosol global indirect / direct and total forcing.
6. Research on post launch MODIS algorithm for dust over desert
7. Research on post launch algorithm for MODIS / AERONET derived single scattering albedo
8. Study of possibility of improvement of the level 3 algorithm by selectively harvesting the MODIS data at specific scattering angle.
9. Study the effect of dust nonsphericity on remote sensing of aerosol and aerosol forcing.

1. Version 2 Algorithms

All algorithms completed, integrated, submitted and accepted. The combined program was tested using synthetic data. It runs successfully. The independent ocean algorithm was further tested using TARFOX MAS imagery with UKMO C130 aerosol size information. The land algorithm was tested against AERONET data. Good results with both algorithms. Stand alone precipitable water vapor tested with SCAR-B MAS measurements showed large discrepancy between 0.91 and 0.94 micron channel. A weighting function will be applied to these two channels.

2. QA plan presented

Atmospheres QA plan presented at EOS-QA workshop July 9-10. QA plan still to be finalized. Meeting scheduled for January 1998.

3.Field Experiment (SCAR and TARFOX) Data Analysis

SCAR:

1) Analysis of MAS imagery from SCAR-B to determine fire characteristics and possible link between fires, burn scars and smoke emissions. Paper submitted to SCAR-B special issue.
2) Smoke aerosol model completed from 3-year AERONET data base and tested. Sensitivity to refractive index and ω_0 determined. Air mass parameterization by precipitable water vapor shown to be no better than parameterization by optical thickness. Paper submitted to SCAR-B special issue.
3) MODIS aerosol over land algorithm applied to SCAR-A and SCAR-B AVIRIS and MAS imagery above co-located AERONET radiometers for validation. Paper submitted to SCAR-B special issue.
4) New technique to derive real part refractive index from sky measurements developed. Paper submitted to SCAR-B special issue.

5) Analysis of ground-based DMPS data at Cuiaba to determine size distribution and Cloud Condensation Nuclei (CCN) characteristics. Comparisons with cascade impactor data at Cuiaba and DMPS data collected during TARFOX. Paper submitted to SCAR-B special issue.

6) SCAR-B AVIRIS targets analyzed for ω_0

TARFOX:

1) Analysis of TARFOX DMPS data, concentrating on calculations of humidification factor. Investigated the similarity in TARFOX and SCAR-B CCN characteristics despite different humidification factors.

2) TARFOX MAS imagery used to test MODIS retrieval algorithms over sea. The ocean retrieval shows generally favorable results when compared to in situ measurements. In particular, comparisons of effective particle size between the retrieval and in situ measurements aboard the UKMO C130 aircraft are good. Most of the MAS images are plagued with sunglint which makes retrieval difficult. Questions about the retrieval remain. We hope to submit a paper to the TARFOX special issue Part II in mid-1998.

3) Analysis of SCAR-A and TARFOX AERONET data for interannual variability of eastern U.S. aerosol. TARFOX was generally less hazy and more regionally uniform than SCAR-A. However, the important characteristic of a dynamic accumulation mode increasing in particle size with increasing optical thickness dominates the TARFOX data set; thereby, supporting the use of the dynamic model in the MODIS land aerosol algorithm. Paper in preparation for TARFOX special issue, Part I.

4) AERONET size distributions were compared with airborne measurements by the UKMO aboard the C130. Only one case of near simultaneous measurements exists. Unfortunately this case occurred on July 20, an extremely clear day. The two size distributions do not match closely, but both show very little aerosol.

4. Laboratory experiment at USFS Fire Lab

Analysis of fire laboratory data show possibility of routine satellite monitoring of fires and fire products is possible. Products include total mass loss, total carbon burnt and total emitted energy. Preliminary analysis of smoke products as function of fire temperature written into paper submitted to JGR. Plans underway for follow-up experiment covering full spectral and dynamic range of fire radiance.

5. Remote sensing of dust using IR techniques

The development of a new technique for remote sensing of dust over land using IR channels is progressing well. Retrieval of optical thickness is confirmed using ground-based sunphotometry for optical thickness. Column water vapor variability presents a limitation on technique's robustness. Other IR channels that will reduce water vapor effects are currently being explored. Simulations have begun in order to test the observations against theory. Preliminary results written into a paper submitted to JGR.

6. Surface Properties in the Mid-IR and visible channels

The aerosol land algorithm is based on the assumption that we will be able to determine surface reflectance in the visible channels from the reflectance at 2.1 μm. The method uses an empirical relationship between the two spectral regions. In May, we collected spectrometer data from a Cessna aircraft and from a cherry picker in a desert transition zone in Israel. Over 2000 spectra were collected from the mostly barren desert scrub of the south, over wheat fields, pine forests and dry-land crops of the mid-lands to the greener areas of the north. Data was also collected over the Mediteranean at multiple altitudes and angles. Data analysis is underway.

We also have been collecting data over Charles County MD to observe the changing empirical relationship over a typical growing season. We have data from March, April, May, June, July, September and October.

We also intend to use the CAR instrument carried by the Univ. of Washington's C-131 aircraft to test angular characteristics of the empirical relationship.

7. Effect of smoke on column stability

In conjunction with J. Joseph of Tel Aviv University the previous analyses of the radiosonde data in Brazil were re-examined. The problem was better defined and a plan was drawn up. Collaboration with Ming-Dah Chou, Wei-Kuo Tao and Pinhas Alpert was initiated. P. Alpert did some preliminary analysis looking for a biomass burning signature in the IAU data from the Goddard Data Assimilation Office. No defining evidence was found and that method of analysis was discarded. The radiation code of M.-D. Chou was used to investigate the heating rates of an atmospheric column similar to the one used in the Ross and Hobbs (RH) investigative study. The results show a similar heating by the smoke aerosol as RH in the solar spectrum, but the IR spectrum that RH ignore dominates the heating profile and is in turn dominated by the strength of the inversion. A series of sensitivity studies using the Chou code are planned. The ultimate goal will be to run the Tao mesoscale model with an interactive surface and clouds to further understand the factors influencing dynamic stability in Brazil during the dry season.

8. Vegetation Indices

Continued testing of various published vegetation indices (NDVI, ARVI, GARI, NDWI etc) and a new suggested index based on the 1.2 and 2.1 - AFRI (Atmospheric FRee Index) shows the strengths of the new index in smoky situations.

9. SeaWiFS algorithm comparison

The overall purpose of the study is to see if our radiative transfer codes fit the aerosol properties as observed from SeaWiFS. Studied the pigment concentrations derived from 4 CZCS images by the operational algorithm and one we constructed. Although the water leaving radiances differed for the two algorithms, the pigment concentrations were essentially the same.

10. Web Page

A web page is in development to showcase the work and achievements of the Aerosol Research Group. It is expected that eventually not only will current and past research be summarized, but papers and data sets will be made available to web users. Temporary location of the web page is http://www.ezy.net/~jaya/Default.htm

11. MODIS Cloud Mask

The MODIS cloud mask was developed with the primary intent to find clear views of the earth's land and ocean surfaces. In doing so, it identifies many cloud-free but aerosol-laden scenes as being "obscured". The atmospheres group has had to customize the cloud mask in order to use the information to eliminate cloudy scenes without throwing away heavy aerosol. This has been an involved process and is still underway.

12. Meetings attended

TARFOX workshops--Jan., May, Dec. (Remer,Tanré, Ji)
AMS in Long Beach--Feb. (Remer)
AGU spring meeting with SCAR-B and TARFOX special sessions--May (Kaufman, Tanré, Remer, Fraser, Wald,Ji, Li, Chu, Kleidman, Mattoo, Ramaprasad)
EOS QA workshop--July (Chu)
IAMAP in Australia--July (Wald)
New Hampshire--Sept. (Kaufman)
MTPE and SIMBIOS review (Fraser)
AAAR in Denver--Oct. (Kaufman, Ji)
AGU fall meeting --Dec. (Remer, Ji)
GEWEX aerosol meeting in San Francisco - Kaufman
Workshop on remote sensing of aerosol, in Maratea - Kaufman

13. Papers Published in special issue on Remote Sensing of Aerosol

JGR special issue on Passive Remote Sensing of Tropospheric Aerosol and Atmospheric Correction for the Aerosol Effect by Y.J. Kaufman, D. Tanré, H.R. Gordon and T. Nakajima appeared in the July 27, 1997 issue of JGR. Papers appearing in the special issue include:

Fraser, R.S., S. Mattoo, E.-N. Yeh and C.R. McClain, Algorithm for atmospheric and glint corrections of satellite measurements of ocean pigment., *J. Geophys. Res.*, *102*, 17107-17118, 1997.

Kaufman, Y.J., D. Tanré, H.R. Gordon, T. Nakajima, J. Lenoble, R. Frouin, H. Grassl, B.M. Herman, M.D. King and P.M. Teillet, Passive remote sensing of tropospheric aerosol and atmospheric correction for the aerosol effect., *J. Geophys. Res.*, *102*, 16815-16830, 1997.

Kaufman, Y.J., D. Tanré, L.A. Remer, E. Vermote, A. Chu and B.N. Holben, Operational remote sensing of tropospheric aerosol over land from EOS moderate resolution imaging spectroradiometer., *J. Geophys. Res.*, *102*, 17051-17067, 1997.

Remer, L.A., S. Gassó, D.A. Hegg, Y.J. Kaufman and B.N. Holben, Urban/industrial aerosol: Ground-based sun/sky radiometer and airborne in situ measurements., *J. Geophys. Res.*, *102*, 16849-16859, 1997.

Tanré, D., Y.J. Kaufman, M. Herman and S. Mattoo, Remote sensing of aerosol properties over oceans using the MODIS/EOS spectral radiances., *J. Geophys. Res.*, *102*, 16971-16988, 1997.

Vermote, E.F., N.E. Saleous, C.O. Justice, Y.J. Kaufman, J.L. Privette, L.A. Remer, J.C. Roger and D. Tanré, Atmospheric correction of visible to middle-infrared EOS-MODIS data over land surfaces: Background, operational algorithm and validation., *J. Geophys. Res.*, *102*, 17131-17141, 1997.

14. Other Papers Published during 1997 or accepted

Kaufman, Y.J. and R.S. Fraser, The effect of smoke particles on clouds and climate forcing., *Science*, *277*, 1636-1639, 1997.

Kaufman, Y.J., A.E. Wald, L.A. Remer, B.-C. Gao, R.-R. Li and L. Flynn, The MODIS 2.1 μm Channel - Correlation with visible reflectance for use in remote sensing of aerosol., *IEEE Trans. Geo*, *35*, 1286-1298, 1997.

Pinker, R.T. , R.A. Ferrare, A. Karnieli, T.O. Aro, Y.j. Kaufman and A. Zangvil, Aerosol optial depth is semiarid region, JGR-Atmosphere, 102, 11123-11137, 1997

Vermote, E., N. El Saleous, Y.J. Kaufman, E. Dutton, Data Pre-Processing: Stratospheric aerosol perturbing effect on the remote sensing of vegetation: Correction method for the composite NDVI after the Pinatubo Eruption., Remote Sensing Reviews, 15, 7-21, 1997.

Hegg, D.A. , Y.J. Kaufman, Measurements of the relationship between submicron aerosol number and volume concentrations, accepted to JGR

15. Papers submitted

The following papers have been submitted to the SCAR-B special issue of JGR.

Chu, D.A., Y.J. Kaufman, L.A. Remer and B.N. Holben, Remote sensing of smoke from MODIS airborne simulator during the SCAR-B experiment., *J. Geophys. Res., submitted to the SCAR-B special issue.*

Ji, Q., S.-C. Tsay, Y.J. Kaufman, G. Shaw and W. Cantrell, Ground-based measurements of aerosol characteristics in biomass burning and industrial pollution episodes *J. Geophys. Res., submitted to the SCAR-B special issue.*

Kaufman, Y.J., P.V. Hobbs, V.W.J.H. Kirchoff, P. Artaxo, L.A. Remer, B.N. Holben, M.D. King, D.E. Ward, E.M. Prins, K.M. Longo, L.F. Mattos, C.A. Nobre, A.M. Thompson, J.F. Gleason and S.A. Christopher, The Smoke Cloud and Radiation Experiment in Brazil *J. Geophys. Res., submitted to the SCAR-B special issue* .

Kaufman, Y.J., R.K. Kleidman and M.D. King, SCAR-B Fires in the Tropics: Properties and their Remote Sensing from EOS-MODIS, *J. Geophys. Res., submitted to the SCAR-B special issue.*

Remer, L.A., Y.J. Kaufman, B.N. Holben, A.M. Thompson and D. McNamara, A model of tropical biomass burning smoke aerosol size distribution., *J. Geophys. Res., submitted to SCAR-B special issue.*

Wald, A., Y. Kaufman, R. Susott, R. Babbitt, D. Ward, M.A. Davies, A. Abtahi, A. Korb, Laboratory Studies of Radiant and Gaseous Emission from biomass burning for use in Remote Sensing. ., *J. Geophys. Res., submitted to SCAR-B special issue.*

Yamasoe, M.A., Y.J. Kaufman, O. Dubovik, L.A. Remer, B.N. Holben and P. Artaxo, Retrieval of the real part of the refractive index of aerosols from sun / sky radiometers *J. Geophys. Res, submitted to the SCAR-B special issue.*

Dubovik, O. , B.N. Holben, Y. Kaufman, M. Yamasoe, A. Smirnov, D. Tanre, I. Slutsker, Single-scattering albedo retrieval from the sky-radiance measured by ground based sun-photometer, submitted to J. Geophys. Res. special issue on SCAR-B

Other papers submitted during 1997.

Alpert, P. , Y. J. Kaufman, Y. Shay-El, D. Tanre, A. da Silva, S. Schubert, Y. H. Joseph, A First Inference of Atmospheric Response to Dust Forcing from a Data Assimilation System, submitted to Nature April 97 revised Aug 97

Kaufman, Y. J. C. Justice, L. Flynn, J. Kandall, E. Prins, D. E. Ward, P. Menzel and A. Setzer, Monitoring Global Fires from EOS-MODIS, submitted to JGR special issue on EOS

Gao, B.-C., Y.J. Kaufman, W. Han and W.J. Wiscombe, Correction of thin cirrus path in the 0.4-1.0 µm spectral region using the sensitive 1.375 µm cirrus detection channel, submitted to JGR special issue on EOS

Polissar, A.V., P.K. Hopke, P. Paatero, Y.J. Kaufman, D.K. Hall, B. A. Bodhaine, and E.G. Dutton, Long term trends and seasonal variations of aerosol concentration at Barrow, Alaska, *J. Geophys. Res. submitted*, 1997.

Remer, L.A. and Y.J. Kaufman, Dynamical aerosol model: Urban/industrial aerosol., *J. Geophys. Res., submitted*, 1997.

Wald, A.E., Y. J. Kaufman, D.Tanré, and B-C. Gao, Daytime and Nighttime Detection of Mineral Dust over Desert using the Thermal Infrared. *J. of Geophys. Res., submitted.* 1997.

Ferrare, R.A. , S.H. Melfi, D.N.Whiteman, K.D. Evans, M. Poellot, R. Leifer , Y.J. Kaufman, Raman Lidar measurements of aerosol extinction and backscattering over the central United States, submitted to JGR.